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От инвалидности к улучшению через протезы

Статья рассказывает о последних разработках в области биопротезирования. Описаны возможности современных электронных биопротезов, их интерфейсы, а также компании, занимающиеся разработкой таких биопротезов в разных странах.

From Disability to Improvement through Prostheses

People are known to change their environment to suit their needs and achieve goals. A lot has been done for human proliferation. However, one thing is limiting possibilities of people. Despite the fact that a human body is very durable as compared to other species, it stops us from exploring new places. For example, space exploration is now presented mostly by remote controlled robots, and no man has ever been further than the Moon`s orbit. Space is a harsh place, with nothing to sustain a life in any form. A lot of efforts go into finding a way to sustain a life where it is never meant to be.

A possible solution comes from somewhat unexpected angle, though.

The history of prosthetics starts in the New Kingdom of Egypt, where the first prosthetic toe was found [3]. Another famous example is a prosthetic arm used by Götz von Berlichingen (1480–1562), a German (Franconian) Imperial Knight. He lost his right arm during the siege of the city of Landshut. Two prostheses were made for him, the second of which is the most famous one. It was made of iron and was capable of holding shields, reins and quills [5].

Modern prostheses research has new challenges to accomplish.

Hugh Herr (born 1964) was a rock climber since his childhood, being recognized as one of the best rock climbers in the USA by the age of 17. In

1982, he spent three days in very low temperatures after getting into blizzard. After rescue, both his legs had to be amputated below the knees. After receiving his prostheses, he realized that they can be changed, unlike a human body, and be able to do a lot of different activities which are normally not possible for a human. He said to himself that it was not the body that restrained many people but the technology, and technology could be improved. He started with developing special limbs that allowed him to return to climbing again.

Today Hugh Herr is a head of Biomechatronics research group at the MIT Media Lab. Here he is engaged in constructing advanced prostheses. During TED 2014, he demonstrated a neural controlled leg prosthesis, which allowed him to run. There has been a lot of work put into that.

There are three interfaces for bionic limbs: mechanical, dynamic and electrical.

The mechanical interface defines how the limbs are attached to the body. Different measurement tools, such as MRI and actuators, are being used to figure out the location of bones, tissues and their compliance. These data are used to create the shape of prostheses, but there is more to it. It is possible to create the material that changes their stiffness. It allows more control over the prostheses. When you walk, they can be made soft for more comfort, and hard when more control is needed.

The dynamic interface is about redoing what usually muscles do. First, you have to collect data on how normal human muscles operate, what forces act in them, where and when they are applied. It allows to create a prosthesis that emulates a human leg during walk. On the heel strike, it becomes stiff to attenuate the shock of the limb hitting the ground. Then the limb pushes the leg forward on mid-stance. All this makes using steps, walking, and running much easier.

The electrical interface allows you to communicate with a prosthetic limb only with your thoughts. The electrodes can measure electrical pulses of the muscles. When a person thinks about moving their limb, the prosthesis can read these signals and act accordingly.

With this technology, Hugh Herr was able to return Adrianne Haslet-Davis, a ballroom dancer, who lost her left leg in the Boston terrorist attack, back to the dance floor [4].

One thing still wasn't mentioned. All of the technologies above allowed better control over the prosthetic limb, but without any neural feedback, the recovery may never be complete. You need to feel your limbs.

This technology is being researched at the Johns Hopkins` Applied Physics Lab and funded by DARPA (Defense Advanced Research Projects Agency).

Melissa Loomis lost her right arm due to the raccoon`s bite, which caused a severe infection. Her only desire is to be able to do usual everyday routines like she used to do before the loss.

Some patients go through surgery called “targeted muscle reinnervation”, which allows using nerves normally connected to the limb, for the prosthesis control. But Melissa`s case was special. Dr. Ajay Seth, an orthopaedic surgeon, was able to do “targeted sensory reinnervation”. It allows to use sensory nerves of the lost limb again. He found and connected the nerves, which were connected to Melissa’s fingers, to the skin on her arm. Now, when something touches the skin in these spots, Melissa actually feels the touch to her now lost fingers.

Later, they placed electrodes on the reinnervated spots on her skin and connected them to the sensors on a robotic arm. The sensors generate a signal, when something touches them; send it to the electrodes on the arm, allowing Melissa to feel through the robotic arm. She is able to tell which finger is being touched now, and grab things using only her touch feel. Without neural feedback, this would be impossible [6].

There are also Russian companies engaged in making bionic prostheses represented on the market.

The “Motorika” company was created on the basis of ITMO University and the Skolkovo Foundation. They make prostheses and other devices to restore finger functionality. Their main product is “KIBI” prostheses. It allows to replace the amputated hands. Their main goal is to help kids with hand traumas. Kids are special case, because they grow fast and often replacement of prostheses is needed. “Motorika” uses 3D-printed prostheses made individually for each case. The technology allows to reduce the cost of each prosthesis and make it affordable for more families. The prostheses for kids also can be customized to have flashlight, compass, MP3-player, etc.

“Motorika” also makes myoelectric prostheses for adults. The technology is the same, but it allows controlling the prosthesis with muscles [1].

Another company is “Can Touch” – they make prostheses for children in collaboration with “W.E.A.S. Robotics”. They also use 3D-printed parts and work individually with each patient [2].

For this moment, humanity starts to acknowledge the possibilities of artificial prostheses. Today it is a rare technology, but tomorrow it is going to be available for masses. Nobody will stop at just returning to what it had once been. We will be able to change our bodies in the ways we cannot imagine yet. The brain-machine interface may change communication, as we know it. So maybe the solution to the further expansion is in changing ourselves rather than in changing the environment around us.

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